HULL ADHESION CHARACTERISTICS OF EARLY-SPLIT AND NORMAL PISTACHIO NUTS

T. C. Pearson, D. C. Slaughter, H. E. Studer

ABSTRACT. *The hull adhesion properties of early-split and normal pistachio nuts were studied to determine the feasibility of separating early-split nuts from normal nuts by their hulling characteristics. The hulls of pistachio nuts were found to adhere more tightly to the shells of early-split nuts than to normal nuts. Laboratory hulling tests on pistachio nuts harvested in 1993 indicated that under controlled conditions, 98% of the normal nut hulls were removed while only 9% of the early-split hulls were removed.* ***Keywords.*** *Pistachio nuts, Aflatoxin, Sorting, Physical properties.*

Pistachio nuts are characterized by a split in the shell along the suture at the calyx end of the nut. This split normally occurs on the tree about a month before harvest. The hull (mesocarp) of the pistachio usually encloses the shell and remains intact through harvest, serving as protection for the kernel after the shell splits open. On normal nuts, there is space between the hull interior and shell exterior, so the shell can split open without splitting the hull. However, about 1 to 4% of the time, the hull will adhere tightly to the shell and the hull will split open along with the shell [T. C. Pearson, "Separating early-split from normal pistachio nuts for removal of nuts contaminated on the tree with aflatoxin" (M.S. thesis, University of California, Davis, 1994)]. These nuts are called "early-splits".

The split in the hull of early-split pistachios allows an unobstructed passage to the kernel for airborne mold spores and insects or other small animals, such as mites, that might be carrying mold spores (Sommer et al., 1986). The mold *Aspergillus flavus*, which creates aflatoxin, can enter the nut through the early hull split. Sommer et al. (1986) found the incidence of aflatoxin contamination to be about 50 times greater in early-split nuts than in non-split nuts (1 in 500 for early-split nuts vs. about 1 in 25,000 of all nuts). Doster and Michailides (1991) found that early-split nuts with dry, shriveled hulls were three times more likely than other early-split nuts to be infested with *Aspergillus flavus*. Furthermore, aflatoxin was found in 31% of the shriveled early-split nuts at an average concentration of 31 ppb. Aflatoxin was seen in only 6% of the nonshriveled early-split nuts at an average concentration of 0.4 ppb (Doster and Michailides, 1993). A need exists for a method to separate early-split pistachio nuts because of their tendency for high aflatoxin content.

Another kind of split that can occur on a pistachio hull shortly (less than 15 days) before harvest is called a growth-split. Growth-splits on pistachio hulls are characterized by ragged brown edges, and the split is randomly oriented and much wider than an early-split. It has been shown that these nuts do not contain aflatoxin or *Aspergillus flavus* at harvest time, presumably because the mold has not had time to develop (Sommer et al., 1986). For the purposes of this study, growth-split nuts are not considered a health risk and are classified as normal nuts along with non-split nuts.

Work to remove aflatoxin-contaminated pistachio nuts has been performed by McClure and Farsaie (1980) and Farsaie et al. (1981). They developed an electronic detector for ultra-violet (UV) fluorescent pistachio nuts. *Aspergillus flavus* also excretes kojic acid which, after reaction with plant tissue, is fluorescent after UV illumination (Marsh et al., 1969). However, it has not yet been shown that there is a direct correlation between aflatoxin content and florescence in pistachios. Steiner et al. (1992) found non-fluorescent pistachio and brazil nuts with high concentrations of aflatoxin and fluorescent nuts with low concentrations of aflatoxin.

Pearson et al. (1994) observed that hull adhesion characteristics might be used to separate early-split pistachios. It is likely that the hulling equipment currently in use at processing plants could be slightly modified to perform a differential hulling treatment. Nuts that do not hull would be removed by normal pistachio processing quality control equipment currently in use. In a processing plant, the nuts are dropped into water after hulling. The unhulled nuts tend to float and are skimmed off while most of the hulled nuts sink. Any *Aspergillus flavus* that is spread during bulk hulling would not have an opportunity to grow as nuts are dried to a moisture content below that which *Aspergillus flavus* grows within a few hours after hulling. Before final packaging, pistachio nuts are also inspected manually and by electronic color sorters to remove unhulled nuts. It is likely that most unhulled nuts are removed at some point during normal processing. However, these unhulled nuts are shelled and used in cake mix and ice cream.

Article has been reviewed and approved for publication by the Food and Process Engineering Inst. of ASAE.

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  0883-8542 / 96 / 1202-0219

The goal of this research was to determine if differences in hull adhesion can be used to separate early-split from normal pistachio nuts. The specific objective was to investigate the hull adhesion characteristics of early-split and normal pistachio nuts.

Methods and Materials

Due to differences in hull adhesion characteristics, early-split nuts were classified in this study into two subcategories: shriveled early-split nuts and nonshriveled early-split nuts. The shriveled early-split nuts had brown, dry, shriveled appearing hulls while the non-shriveled early-split nuts had green, non-shriveled hulls and a straight, dark-edged lesion on the suture of the nut. For similar reasons, normal nuts were classified in this study into two subcategories: non-split nuts and growth-split nuts. A non-split nut had a non-shriveled hull with no lesions present while growth-split nuts had an irregularly shaped lesion in the hull not characteristic of an early-split lesion.

During the 1992 harvest season, three orchards were sampled in California's San Joaquin Valley, where most of the pistachios in the United States are grown. The sampling was performed early (4 September 1992), mid (22 September 1992), and late (30 September 1992) in the harvest season. During the 1993 harvest season, five orchards were sampled. Samples were collected from the same three orchards studied in 1992 and from two orchards located in the Sacramento Valley, about 322.6 km (200 mile) north of the San Joaquin Valley orchards. The 1993 sampling dates were dispersed throughout the harvest season with sample dates on: 7, 13, 20, 27 September, and 5 October. One orchard was sampled on each sample date.

When samples were collected, the nuts were separated into split types and placed in bulk in quart-sized zip lock polyethylene bags. The bags of nuts were then placed in a gallon-size polyethylene zip lock bag which was placed in an ice chest for transport to the laboratory.

Two devices were used to quantify the hull adhesion of nut types. The first device, called the tumbler, was constructed from a 40 cm (15.75 in.) diameter PVC pipe and lined on the inside with 18 pieces of 1.75 cm (0.69 in.) steel angle irons for vanes (fig. 1). Samples of a hull-split type were placed in the tumbler. The tumbler was rotated at 13 rpm. The tumbler rotation was stopped every 30 s and the quantity of nuts that had been separated from their hulls was recorded, but all nuts remained in the tumbler for the duration of the test (10 min). A nut was considered separated from its hull when more than 50% of the hull became completely detached from the shell. In 1992, a single 30-nut sample of each split type was tested at each of the three harvest dates. During the 1993 harvest season, three 20-nut samples (60 nuts total) of each hull-split type were tested at each harvest date. A total of 390 nuts of each hull-split type were tested in the tumbler in 1992 and 1993.

Commercial hulling devices operate by inducing pressure upon the nuts and rotating them against a steel plate or other nuts. This results with the hull being sheared and pulled off due to the friction between the hull and other nuts or the hulling device. This action is different than that applied by the tumbler where the hulls are repeatedly dropped until the nut falls out of the hull. Thus, in 1993 a second device, called the spin huller (fig. 2) was developed to evaluate hulling properties in a manner similar to commercial hulling operations. This device consisted of a variable speed right angle drill (Makita, DA3000R) with a 16 grit, 13 cm (5.1 in.) diameter sanding disk attached. Surrounding the sanding disk was a 14 cm (5.5 in.) inside diameter aluminum pipe. The inside of the pipe was lined with 40 grit sandpaper. Essentially, this device worked like a small-scale potato peeler. The nuts were placed on the spinning sanding disk and the centrifugal force threw the nuts against the inside of the pipe wall. The nuts rubbed or bounced along the inside surface of the pipe. The friction between the nut and sandpaper on the pipe and sanding disk eventually tore and separated the hull from the shell. For normal nuts, where the hull typically is loosely attached to the shell, the hulls usually sheared in half and the nut easily fell out. Occasionally the hull was worn or ground off by the sandpaper.

The drill speed was measured with a hand held tachometer (Ametek, 1726) and set at 900 RPM. From each of the five harvest samplings in 1993, 40 nuts of each split type were placed individually in the spin huller for a maximum of 40 s. Thus a total of 200 nuts of each split type were individually tested. The time for the nut to become hulled was recorded. If the nut was not hulled within 40 s, it was noted. A nut was considered hulled if

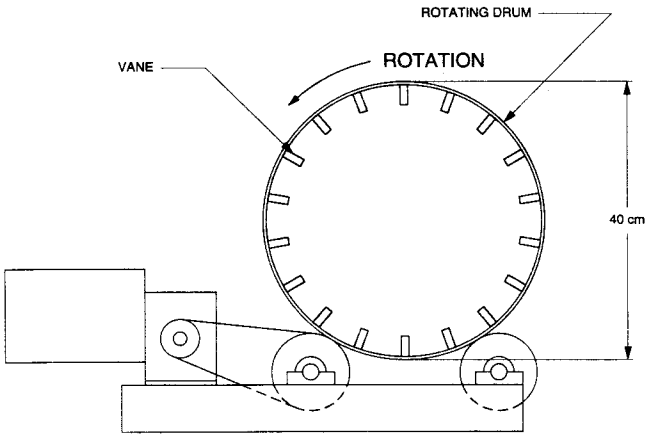

Figure 1–Tumbler device.

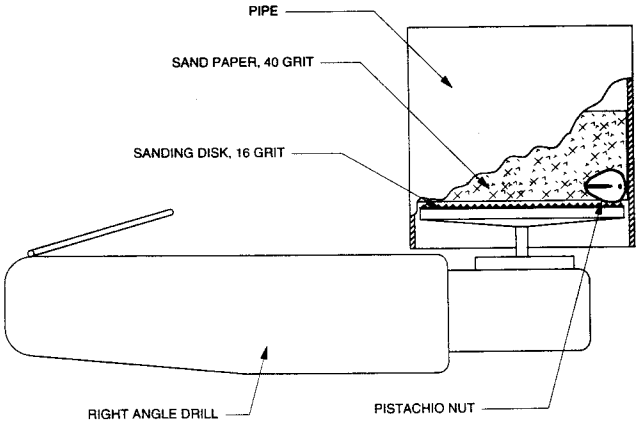

Figure 2–Spin huller.

more than 50% of its hull was completely separated from the shell.

Results and Discussion

In the 1992 tumbler tests it was observed that normal nuts were hulled in less time than early-split nuts. Ninety-five percent of the growth-split and 91% of non-split nuts became separated from their hulls in 180 s. Only 2% of the non-shriveled early-split nuts lost their hulls before 180 s.

Similar results were obtained for the 1993 tumbler tests: 100% of the non-split and 97% of the growth-split nuts were hulled within 180 s. Only 9% of the non-shriveled early-split and none of the shriveled early-split nuts were hulled within 180 s. The shriveled early-split nuts were particularly difficult to hull with only 3% being hulled after 10 min in the tumbler. Figure 3 shows the percent of nuts hulled versus time for all of the nuts tested with the tumbler in 1993.

With the spin huller, 99% of the non-split and 92% of the growth-split nuts were hulled within 20 s. Conversely, only 7% of the non-shriveled early-split and 1% of the shriveled early-split nuts hulled within 20 s. Figure 4 shows the hulling percentages versus time for all of the nuts tested in the spin huller in 1993. On approximately 10% of the non-shriveled early-split nuts, half of the hull was separated from the shell in less than 40 s while half of the hull remained attached for 40 s. These partially hulled nuts were recorded as unhulled.

Doster and Michailides (1993) concluded that shriveled early-split nuts were much more likely to be contaminated with aflatoxin. Therefore, many of the aflatoxin contaminated pistachio nuts might be removed by a differential hulling process. More study needs to be performed to determine the aflatoxin content of green early-split nuts that are easily separated from their hulls. This would determine the extent of aflatoxin that could be removed by a hulling process.

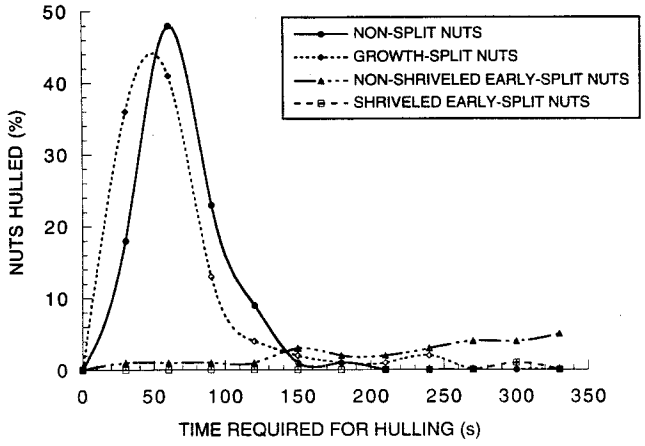

Figure 3–Distribution of nuts hulled in the tumbler.

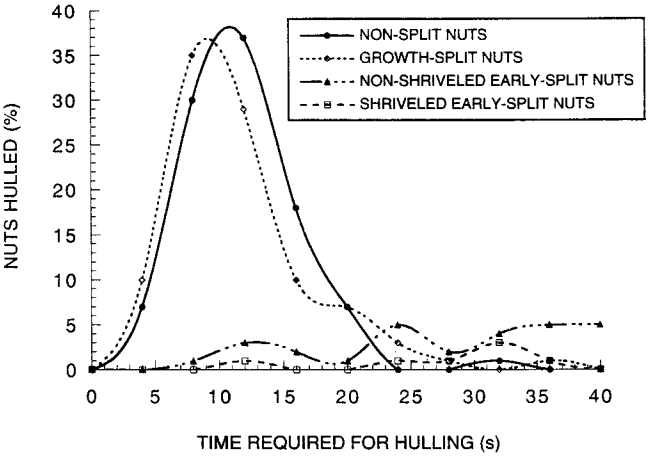

Figure 4–Distribution of nuts hulled in the spin huller.

Conclusion

Results show that there are substantial differences in the hull adhesion characteristics of normal and early-split pistachio nuts. These hull adhesion results were confirmed by results from two years of study using two different hulling devices.

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